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(12) # EUROPEAN PATENT APPLICATION

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(54) **Torque tube assembly.**

(57) A torque tube employing end members (4, 6) interconnected by a tubular member (2). The end members (4, 6) are provided with a male extension (20) having radially spaced, axially extending grooves (16), the number of grooves, outer diameter of the end member, groove width and groove length being in prescribed proportions and ratios. The ends of the tubular member are positioned over the male end member shoulders (24, 26) and the tube walls are conformed to the end member (20) and grooves electromagnetically so that the tube walls are recessed into the grooves.

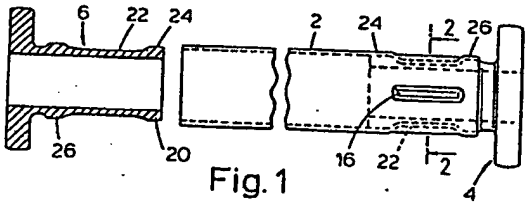

Fig. 1

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TORQUE TUBE ASSEMBLY

The present invention relates to the assembly and attachment of tubular parts to mating members and, more particularly, to the assembly and attachment of metal tubes to end fittings to form torsion members.

It is common practice such as, for example, for use in aircraft and aerospace vehicles, to make torque or torsion members by connecting the ends of a tubular member to preformed members formed and adapted to fasten and interconnect the assembled torque or torsion member to the elements between which torque or torsion is to be transmitted. The tubular member transmits the torque or torsion between the preformed end members and allows for a substantial reduction in the overall weight of the assembly. This is, of course, of substantial importance in aircraft and aerospace vehicles.

Various arrangements have, heretofore, been employed in interconnecting the ends of the tubular member to the preformed ends. Thus, the surface of the preformed ends to be mated with the tube have been provided with teeth, serrations or grooves and the tube end which is slipped over the teeth, serrations or grooves, has been crimped or compressed causing the teeth, serrations or grooves to bite into the inner tube wall. To be effective in such arrangements, the mating surface and inner tube wall must fit snugly and close production tolerances are required. Furthermore, the teeth, serrations or grooves biting into the inner tube wall and the tool used to crimp or compress the tube onto the end member cause stress points or areas on the tube which, during use, can result in fatigue or stress failures. In an aircraft or aerospace vehicle such failures are, of course, undesirable.

U.S. Patent No. 3,837,755 shows and describes a tubular control or pushrod in which a tubular member is connected, at its ends, to fitting members provided with circumferential grooves of specified width, depth and side wall configuration. The tube end is slipped over the grooves and the tube is compressed into the grooves. The control or pushrod of the patent is for axial operation and replaces a rivet attachment. When actuated axially, according to the patent, the grooved arrangement of the patent has an axial failure strength almost three times the axial strength of the conventional riveted control rod.

In the present invention, it has been discovered that the grooving and forming arrangement of U.S. Patent No. 3,837,755 can be adapted to torque or torsion transmitting tubes and a member can be produced wherein the torque or torsion strength of the tube at the end connection exceed the torsional buckling and failure strength of the tube, itself. It has been discovered that, by extending the grooves axially of the tube and by maintaining the groove side walls at an angle within prescribed limits, the number of grooves to the outer diameter of the end fitting and groove width at a prescribed ratio, the groove depth to the groove width within a prescribed ratio and the axial length of the grooves longer than the circumferential groove width, the advantages of the present invention can be attained.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a side view, broken and partly in section, of an embodiment of a torque or torsion tube of the present invention;

Figure 2 is a cross sectional view taken at 2-2 in Figure 1;

Figure 3 is an enlarged view of a portion of the cross section in Figure 2; and

Figures 3a and 3b are views similar to Figure 3 but showing the base of the groove curved outwardly and curved inwardly, respectively.

Figure 1 shows a tube 2, which may be of standard wall thickness, for example, aluminum tubes having wall thickness of 0.058 in (1.473 mm) and tubes having a wall thickness of 0.095 in (2.413 mm) have been used, connected in accordance with the invention to an end member 4 and before assembly at its other end to a second end member 6. In the illustrated embodiment, the end members 4 and 6 are identical. However, the end members may be of different configuration if required by the end use for which the unit is assembled.

In the present embodiment, the end members 4 and 6 are each provided with four grooves, equally spaced around the circumference thereof, for example, grooves 10, 12, 14, 16 as shown in end member 4 in Figure 2, and extending axially therealong. The open end of tube 2 is slipped over the male end 20 of the end member 4, 6 and over the axially extending and longitudinally spaced grooves 10, 12, 14, 16 and is compressed thereinto as will be described later. As can be seen from Figure 1, the male end 20 of the end member 4,6 is axially grooved at 22, between shoulders 24, 26. Grooves 10, 12, 14, 16 extend axially between shoulders 24, 26. In assembling the torque tube, the open end of tube 2 is slipped over shoulders 24, 26 and rests thereon when tube 2 is compressed. The depth of the grooves at 22 is selected so that the end of tube 2 can be compressed, as hereinafter described, and thereby recessed into grooves 10, 12, 14, 16 without appreciable stretching, thinning or weakening of the tube wall and, at the same time, without buckling of the wall end of the tube.

As will be understood from Figures 2 and 3, after tube 2 is slipped over male end 20 and onto shoulders 24, 26, the end of tube 2 which extends over grooves 10, 12, 14, 16, is compressed, forcing the material of the tube 2 to conform to the contour of the grooves 10, 12, 14, 16 so as to be recessed therein without substantial stretching or thinning of the tube wall thickness. Compressing the tube end to the contour of the grooves 10, 12 14, 16 can be accomplished by swaging, by explosion forming, by rubber press forming and electromagnetically. Tool marking of the tube wall should be avoided. Preferably, the tube end is compressed and the contouring of the tube wall to the grooves of the end member is accomplished electromagnetically.

In the present embodiment and with reference to Figure 3, groove angle A should not be substantially less than 5° and not substantially more than 60°, the groove width B should not be substantially less than 0.15 in (3.81 mm) and not be substantially greater than 0.45 in (11.43 mm), and the depth C of the groove, as measured vertically at the edge of the groove, should not be less than 0.02 in (0.508 mm) and not substantially greater than 0.10 in (2.54 mm). The edges of the groove at E and F and at the forward and rearward groove ends should have a radius between about 0.01 in (0.254 mm) to about 0.15 in (3.81 mm). A groove side wall and end wall angle of $41.4 \pm 0.5°$, a groove width of 0.298 - 0.302 in (7.569-7.671 mm), a groove depth of 0.034 ± 0.002 in (0.864 ± 0.051 mm) and a radius of 0.020 in-0.30 in (0.508-7.62 mm) has been demonstrated to be the preferred arrangement for a satisfactory torque or torsion tube for most aircraft and aerospace vehicle use.

In the practice of the invention, the ratio of the number of grooves and outer diameter of the end member

or fitting to the groove width, the ratio of groove depth to groove width and groove length to groove width is important. Thus, the number of grooves divided by the outer diameter of the end member or fitting should be equal to or less than 2.1 divided by the groove width; the depth of the groove, as measured at C, Figure 3, divided by the groove width, measured at B, Figure 3, should be equal to or less than 2.0; and, the length of the groove should be greater than the groove width.

In addition to high torque strength, the torque or torsion tube of the present invention, electromagentically assembled, is assembled at a lower cost than conventional crimping techniques. More consistent high conformity of tube to groove, resulting in superior static and fatigue properties are attained for the joint. Assembly of the tube and tube ends is not subject to operator proficiency. Furthermore, the manufacturing tolerance between the tube inner diameter and the outer diameter of the end fitting or member is less critical, reduces dimensions of the tube ends to fit end fitting and further reduces cost.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the present invention.

CLAIMS

1. A torque tube assembly wherein the torsional strength of the end connection exceeds the torsional strength of the tube comprising a pair of end members (4, 6) interconnected by a tubular member (2), each of said end members having a male extension (20) extending into said tubular member, said male members each having a plurality of axial grooves (10, 12, 14, 16) spaced equidistant circumferentially around said male member with shoulders at the opposite axial ends of said grooves, the inner wall of said tubular member resting on said shoulders, end portions of said tubular member intermediate said shoulders being recessed into said grooves and forming a torque transmitting interconnection therebetween, each of said axial grooves comprising a plurality of straight side walls and a bottom member intersecting said side walls, each of said side walls being equally angularly sloped with respect to a vertically disposed plane normal to a horizontally disposed plane passing through intersections of said side walls and an outer surface of said end members, said intersections of said side walls with said outer surface and said bottom member each having a radius.

2. A torque tube assembly, as recited in claim 1, in which the axial length of said grooves (10, 12, 14, 16), between said shoulders is greater than the circumferential width of said grooves.

3. A torque tube assembly, as recited in claim 1 or 2, in which the number of grooves (10, 12, 14, 16) in the end member divided by the outer diameter of the end member (4, 6) is equal to or less than 2.1 divided by the groove width.

4. A torque tube assembly, as recited in any preceding

claim, in which the depth of the groove, as measured substantially vertically at the groove edge, divided by the groove width, measured at the bottom of the groove, is equal to or less than 2.

5. A torque tube assembly, as recited in any preceding claim, in which the angular slope (A) of each of the groove side walls is not substantially less than 5° and not substantially more than 60° with said side walls sloping away from said bottom member of the groove, whereby the angle of slope of said groove side walls is selected in accordance with the wall thickness of said tubular member.

6. A torque tube assembly, as recited in any preceding claim, in which the width of said grooves is not substantially greater than 0.45 in (11.45 mm).

7. A torque tube assembly, as recited in any preceding claim, in which the depth of said grooves measured vertically at the groove edge is not substantially less than 0.02 in (0.508 mm) and not substantially greater than 0.10 in (2.54 mm).

8. A torque tube assembly, as recited in any preceding claim in which said intersections of said side walls with said outer surface and said bottom member have a radius between 0.01 and 0.15 inches (0.254 and 3.81 mm).

9. A torque tube assembly, as recited in any preceding claim in which the width of said grooves is not substantially less than 0.15 in (3.81 mm) and not substantially greater than 0.45 in (11.43 mm).

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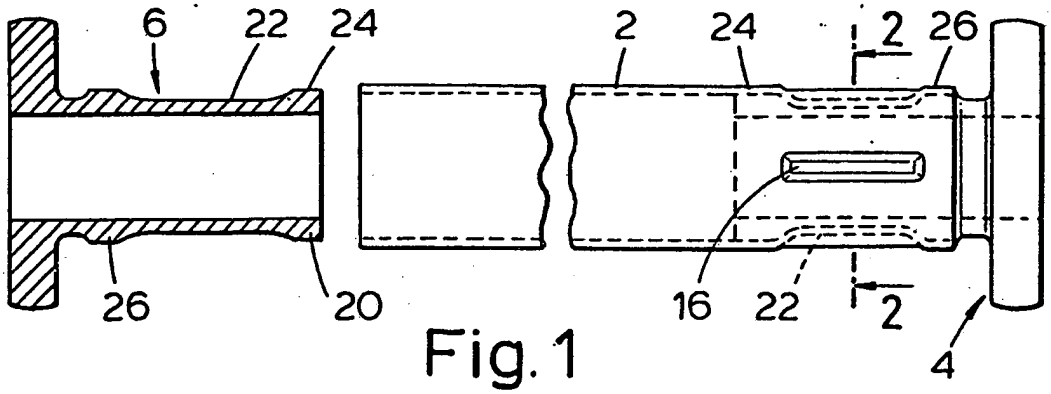

Fig. 1

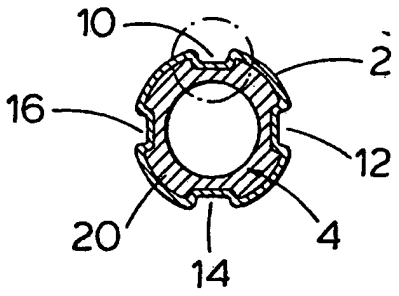

Fig. 2

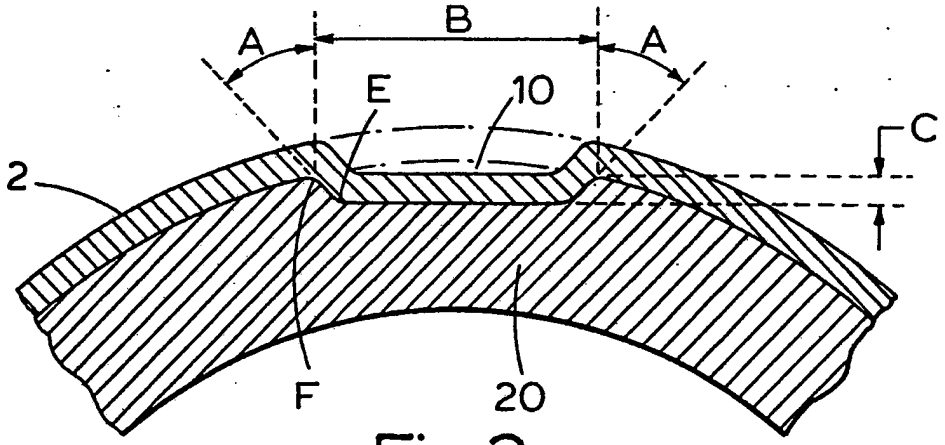

Fig. 3

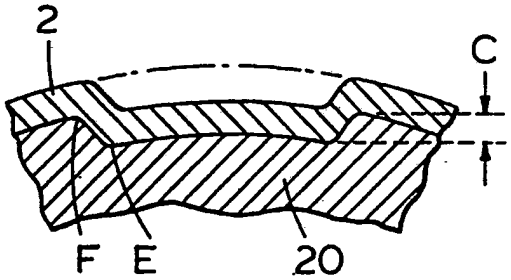

Fig. 3A

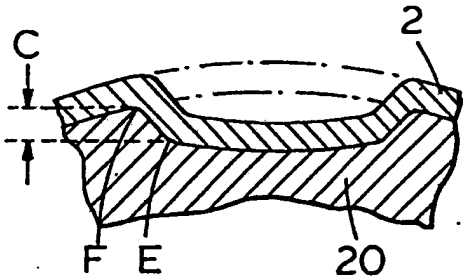

Fig. 3B

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EUROPEAN SEARCH REPORT

0195150
Application number

EP 85 30 1970

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	DE-B-1 107 749 (LICENTIA PATENT-VERWALTUNGS GMBH) * figure 3 *	1,2	F 16 B 7/00
Y	CH-A- 129 362 (FAUDI) * figures 4,14 *	1,2	
Y	US-A-2 596 885 (BOOTH) * figure 1 *	1,2	
Y	US-A-3 642 311 (EDGEMOND) * abstract *	1,2	
A,D	US-A-3 837 755 (BENOIT et al.) * figure 2 *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

F 16 B 7/00
F 16 B 7/04
F 16 B 2/02
F 16 B 4/00
F 16 B 12/50

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	01-10-1985	ZAPP E

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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